

TITLE

5 COLORED THERMOPLASTIC RESIN COMPOSITIONS FOR LASER
WELDING, SPECIFIC NEUTRAL ANTHRAQUINONE DYES AS COLORANTS
THEREFOR, AND MOLDED PRODUCT THEREFROM

This application claims the benefit of U.S. Provisional Application
No.60/247,647, filed November 13, 2000.

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FIELD OF THE INVENTION

The instant invention relates to thermoplastic resin compositions with specific anthraquinone dyes. More particularly, the inventions relates to such compositions having improved laser weldability.

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BACKGROUND OF THE INVENTION

It is known in the art to join together two articles of resins (and respectively opaque and transparent) by positioning them in contact with each other, transmitting a 20 predetermined amount of laser beam focusing on the junction of them and causing the junction portion to be melted and joined together ("laser welding"). Several advantages flow from laser welding versus conventional methods of joining plastic parts.

For example, laser welding is widely known for its simple operation, labor 25 savings, improvement of productivity, clear joints, and reduction of production cost. It is useful in various applications including the preparation of molded articles, including hollow shapes, in automobile industries and electric and electronic industries. Recently, work has intensified in the area of blends of thermoplastic resin and a colorant containing an organic dye or pigment. Better control of the conversion of laser energy 30 to heat is achieved by the addition of such colorants to the resins. Laser beams penetrate through transparent articles positioned closer to the laser beam source, and are largely absorbed in the opaque article, which has a relatively higher absorption coefficient in comparison with the aforementioned transparent article. Careful attention to the amount 35 of the colorants therein results in the junction portion being melted and the articles joined together.

See for example Japanese Published (Koukoku) Patent No.62-49850, and Japanese Published (Koukoku) Patent No.5 (93)-42336. Other resin compositions associated with the laser welding are described in U.S.Pat.No.5,893,959 which discloses 5 transparent and opaque workpiece parts welded together by a laser beam along a joining zone. Both parts contain black dye and pigments such as carbon black to cause them to offer a substantially homogenous visual impression even after welding.

Other illustrations of the laser welding of compositions are found in the 10 5,893,959 patent. For example, the color of the thermoplastic components may be black (carbon black or nigrosine), which is commonly and widely used in the automobile industries and other applications. However, carbon black and nigrosine can not transmit a laser beam with a main wavelength in infra-red region (1200 nm to 800 nm), such as Nd:YAG laser and a diode laser which are of wide use in industries.

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Surprisingly, it has now been found that thermoplastic resin compositions both black in appearance can be used for laser-welded molded articles, and both for the transparent and opaque parts subjected to the laser beam. A significantly improved transmission to near-infrared light of the laser beam, with excellent and balanced heat-resistance and mechanical properties as required in automobile applications is achieved 20 by including a specific weight percentage of black dyes.

The object of the present invention is to offer a thermoplastic resin composition capable of offering moldings which appear in black, offer excellent thermal resistance, 25 and are transparent to a laser beam, in particular to the near-infrared light region. A further object of the invention is to provide select anthraquinone blue dyes which offer minimal discoloration during molding and in high temperature applications. A feature of the invention is the compositions herein can provide a substantially homogenous visual black impression of transparent and opaque articles that appears in black and 30 absorbs the laser beam largely by containing black dyes, welded together by the laser beam, and possess excellent and balanced heat-resistance and mechanical properties as required in automotive parts, electric/electronic components, mechanical components,

and many other applications. The aforementioned objects, features and advantages will become better understood upon having reference to the following description of the invention herein.

SUMMARY OF THE INVENTION

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This invention relates to an improved thermoplastic resin compositions for laser welding comprised of thermoplastic resin and a black colorant comprising at least neutral anthraquinone dye which imparts color of blue, absorbs visible light with wavelength less than 700 nm and transmits a laser beam with wavelength at 800 nm to 1200 nm. In addition to said neutral anthraquinone dye, other red dye which transmit the laser beam with wavelength at 800 nm to 1200 nm in infra-red region, such as perinone dyes or monoazo complex dyes can be present at predetermined weight ratio.

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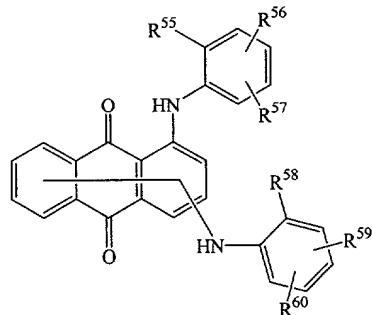
The present invention, which allows the sated objective to be attained, concerns a thermoplastic resin composition for laser welding comprising:

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- 1) thermoplastic resin; and,
- 2) a laser beam transmitting black colorant comprising neutral anthraquinone dye of formula [I] or [II]

wherein formula [I] is

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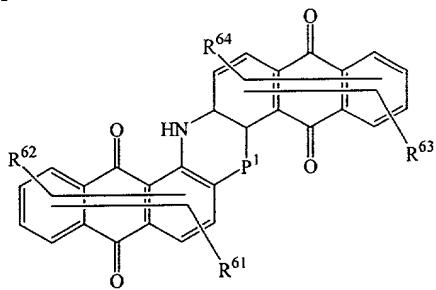
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wherein R⁵⁵ and R⁵⁸, which may be the same or different, are independently selected from alkyl groups having 1 to 18 carbon atoms; and R⁵⁶ and R⁵⁹, which may be the same or different, are independently selected from the group consisting of alkyl, aryl, alkenyl, alkoxy, amino, N-alkylamide, N-arylamide, acyl, acylamide, alkoxycarbonyl, hydroxy, and carboxy groups and halogen atom; and R⁵⁷ and R⁶⁰, which may be the same or different, are independently selected from the group consisting of H, alkyl, aryl, alkenyl, alkoxy, amino, N-alkylamide, N-arylamide, acyl, acylamide, carboxy, alkoxycarbonyl, and hydroxy groups and halogen atom,

10 and wherein formula [II] is

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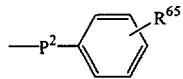


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wherein R⁶¹, R⁶², R⁶³, and R⁶⁴, which may be the same or different, are independently selected from the group consisting of H, alkyl, alkenyl, aryl, alkoxy, amino, N-alkylamide, N-arylamide, acyl, acylamide, carboxy, alkoxycarbonyl, hydroxy group, halogen atom, formula [II-a], and P¹ is NR⁶⁶ or CO, wherein R⁶⁶ is H, alkyl, or aryl groups.

formula [II-a] is:

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10 wherein P² is NH or NHCO; R⁶⁵ is H, alkyl, aryl, alkoxy, amino, hydroxy, or halogen atom.

With these components, thermoplastic resin compositions for laser welding offer improvements in moldability, solubility in the thermoplastic resin, bleeding and
15 blooming-resistance, transparency to wavelengths of a laser beam at 800 nm to 1200 nm and resistance to chemicals. Another advantage is that the composition provides the greater color value to produce the black colorant because of the said neutral anthraquinone dye of formula [I] or [II] as a major component of said colorant and higher heat resistance. Therefore, the compositions of the present invention comprising
20 the black colorant comprising at least said neutral anthraquinone dye as the major component are extremely suitable for thermoplastic resins which requiring melt temperature higher than 300°C during molding operation.

The compositions of the invention may also contain other yellow dyes in
25 addition to the mixture of anthraquinone dyes with red dyes as one of components of black dyes used as a colorant of the composition, preferably anthraquinone yellow dyes.

The actual amount of respective dyes which are useful in the practice of the invention will depend upon kind of thermoplastic resins blended with the dyes, the
30 desired colors, the desired depth of shade and thickness of molded articles of the composition of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

35 The invention will be better understood upon having reference to the drawings herein.

Figure 1 is a view of the articles in contact with and with a laser beam applied thereto; and

Figure 2 is identical to Figure 1, but with the articles of the same color.

Figure 3 illustrates a shape and dimensions of a test piece creating a notch in the test piece (60mm x 18mm).

Figure 4 is a perspective view of test pieces of Fig. 3 disposed close to each other for a laser welding test and relationship between the test pieces and laser beam.

Figure 5 illustrates a shape and dimensions of a test piece creating a notch in the test piece (80mm x 40mm).

Figure 6 is a perspective view of test pieces of Fig.5 disposed close to each other for a laser welding test and relationship between the test pieces and laser beam

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DETAILED DESCRIPTION OF THE INVENTION

Examples of the anthraquinone dyes of Formulas [I] and [II] having the above-mentioned properties used as the main component forming the black dye contained in the composition of the invention are listed in Tables 1 and 2 respectively.

Table1

Pro. Ex. No	R ⁵⁵	R ⁵⁶	R ⁵⁷	R ⁵⁸ ,	R ⁵⁹	R ⁶⁰
I-1	CH ₃	CH ₃	H	CH ₃	CH ₃	H
I-2	CH ₃	CH ₃	CH ₃	CH ₃	CH ₃	CH ₃
I-3	CH ₃	C ₂ H ₅	C ₂ H ₅	CH ₃	C ₂ H ₅	C ₂ H ₅
I-4	C ₂ H ₅	C ₂ H ₅	CH ₃	C ₂ H ₅	C ₂ H ₅	CH ₃
I-5	C ₂ H ₅	C ₂ H ₅	H	C ₂ H ₅	C ₂ H ₅	H
I-6	CH ₃	C ₁₂ H ₂₅	H	CH ₃	C ₁₂ H ₂₅	H
I-7	CH ₃	OCH ₃	H	CH ₃	OCH ₃	H
I-8	CH ₃	CH ₃	Cl	CH ₃	CH ₃	Cl
I-9	CH ₃	CH ₃	C ₄ H ₉	CH ₃	CH ₃	C ₄ H ₉
I-10	CH ₃	CH ₃	OH	CH ₃	CH ₃	OH

Pro. Ex. No. =Product Example Number

Table2

Pro. Ex. No	P ¹	R ⁶¹	R ⁶²	R ⁶³	R ⁶⁴
II-1	NH	OH	H	OH	H
II-2	NH	Cl	H	Cl	H
II-3	NH	H	Br	H	Br
II-4	NH	CH ₃	CH ₃	H	H
II-5	NCH ₃	H	H	H	H
II-6	NH	NH ₂	H	NH ₂	H
II-7	NH	H	H	H	H
II-8	NH	OH	H	H	H
II-9	NH	anilino	H	anilino	H
II-10	NH	benzamide	H	benzamide	H
II-11	CO	NHC ₄ H ₉	H	NHC ₄ H ₉	H
II-12	CO	NH ₂	H	NH ₂	H

Pro. Ex. No. =Product Example Number

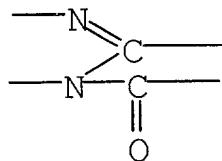
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The above mentioned formula dyes offer superior color value when forming the black color, as well as high heat resistance.

Various additional dyes (like red, orange, and yellow dye forming black color) in 10 the composition of the invention are reviewed below.

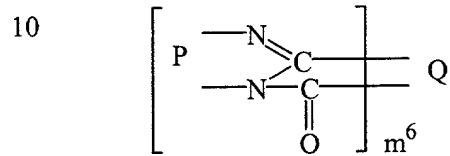
The perinone dyes which are mixed with the above-mentioned anthraquinone dyes for use as a black colorant comprised in the composition of the invention are known products of formula [III].
formula [III]:

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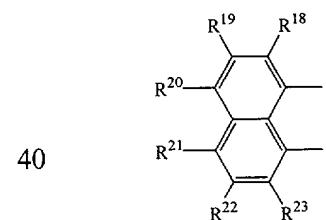
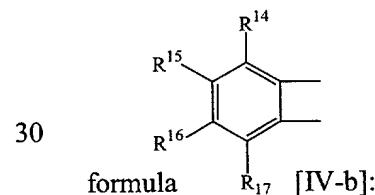
The perinone dyes which are mixed with the anthraquinone to produce a black dye may be used alone or in combination thereof.

Preferred perinone dyes used in the composition of the invention when
5 solubility and / or dispersion in the resin are considered, are those of formula [IV],
formula [IV] :

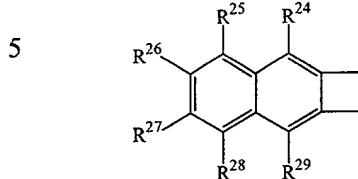


wherein P and Q, which may be the same or different, are independently constituent units which can be represented by the following formula [IV-a] to [IV-c]. R¹⁴ to R²⁹, which may be the same or different, are independently an atom or a group selected from the group consisting of H, halogen atom such as Cl, Br, alkyl group having 1 to 18
20 carbon atoms, alkoxy group having 1 to 18 carbon atoms, aralkyl group, aryl group; m⁶ is the number of 1 or 2.

formula [IV-a]:



formula [IV-c]:



Dyes which belong to the class of perinone dyes listed in color index are for example C.I.Solvent Orange 60, 78, C.I.Solvent Red 135, 162, 178, 179, C.I.Violet 29, C.I.Pigment Orange 43, C.I.Pigment Red 149. If solubility and dispersibility in the resin
15 are enhanced, solvent type dyes are preferred.

Examples of the perinone dyes of formula [IV] are illustrated below in Table 3.

Table3

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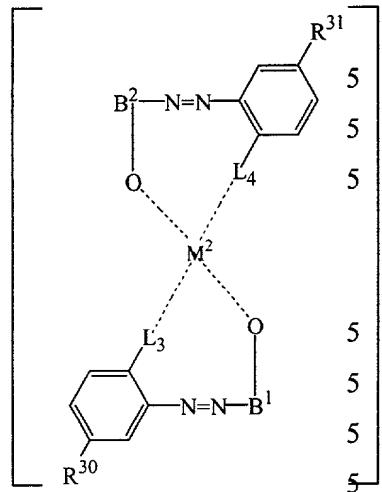
Pro. Ex. No	P	Q	m^6
IV-1	Formula [IV-b], $R^{18}=R^{19}=R^{20}=R^{21}=R^{22}=R^{23}=H$	Formula [IV-a], $R^{14}=R^{15}=R^{16}=R^{17}=H$	1
IV-2	Formula [IV-b], $R^{18}=R^{19}=R^{20}=R^{21}=R^{22}=R^{23}=H$	Formula [IV-a], $R^{14}=R^{15}=R^{16}=R^{17}=Cl$	1
IV-3	Formula [IV-b], $R^{18}=R^{19}=R^{20}=R^{21}=R^{22}=R^{23}=H$	Formula [IV-c], $R^{24}=R^{25}=R^{26}=R^{27}=R^{28}=R^{29}=H$	1
IV-4	Formula [IV-a], $R^{14}=R^{15}=R^{16}=R^{17}=H$	Formula [IV-b], $R^{18}=R^{19}=R^{20}=R^{21}=R^{22}=R^{23}=H$	1
IV-5	Formula [IV-b], $R^{18}=R^{19}=R^{20}=R^{21}=R^{22}=R^{23}=H$	Formula [IV-c], $R^{24}=R^{25}=R^{26}=R^{27}=R^{28}=R^{29}=H, R^{25}=OC_2H_5$	1
IV-6	Formula [IV-b], $R^{18}=R^{19}=R^{20}=R^{21}=R^{22}=R^{23}=H$	Formula [IV-a], $R^{14}=R^{15}=R^{17}=H, R^{16}=\text{benzoyl}$	1
IV-7	Formula [IV-b], $R^{18}=R^{19}=R^{20}=R^{22}=R^{23}=H, R^{21}=C_4H_9$	Formula [IV-a], $R^{14}=R^{17}=H$	2
IV-8	Formula [IV-b], $R^{18}=R^{19}=R^{20}=R^{21}=R^{22}=R^{23}=H$	Formula [IV-c], $R^{24}=R^{26}=R^{27}=R^{28}=R^{29}=H, R^{25}=\text{phenyl}$	1
IV-9	Formula [IV-b], $R^{18}=R^{19}=R^{20}=R^{21}=R^{22}=R^{23}=H$	Formula [IV-a], $R^{15}=R^{16}=R^{17}=H, R^{14}=Br$	1
IV-10	Formula [IV-b], $R^{18}=R^{19}=R^{20}=R^{21}=R^{22}=R^{23}=H$	Formula [IV-a], $R^{15}=R^{16}=R^{17}=H, R^{14}=COOH$	1

Pro. Ex. No. =Product Example Number

The monoazo complex dyes which are mixed with the anthraquinone dyes of formula [I] or formula [II] to produce a black dye for use as colorant comprised in the

composition of the invention, can be represented by formula [V].

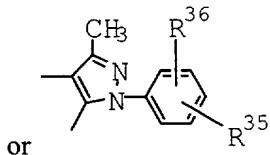
Formula [V] is:



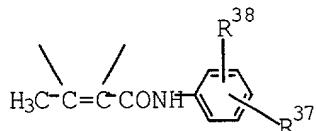
5_{m^2} - wherein R^{30} and R^{31} , which may be the same or different, are Cl , SO_2R^{32} , $SO_2(-R^{33})(-R^{34})$, or H ; wherein R^{33} and R^{34} , which may be the same or different, are independently hydrogen atom, linear or branched C1 - C4 alkyl; $K^{2(D)^+}$ atom, linear or branched C1 - C4 alkyl; L_3 and L_4 are independently O or COO ; $(D)^+$ is hydrogen ion, cation of alkali metals, ammonium ion, cations of organic amine including aliphatic primary, secondary and tertiary amines, or

25 quaternary ammonium ion; K^2 is an integer; m^2 is 0, 1 or 2; , M^2 is selected from metals of ionic valency from 2 to 4 (such as Zn, Sr, Cr, Al, Ti, Fe, Zr, Ni, Mn, B[boron] and Co), preferably metal of trivalent metal such as Cu or trivalent metal such as Cr, Co, Ni, and Al.
and B^1 and B^2 are represented by formula [V-a] or formula [V-b].

30 formula [V-a]:



40 formula [V-b]:



wherein R^{35} and R^{37} , which may be the same or different, are Cl , SO_2R^{32} , $SO_2(-R^{33})(-R^{34})$, or H ; R^{33} and R^{34} , which may be the same or different, are independently hydrogen atom, linear or branched C1 - C4 alkyl; and R^{36} and R^{38} , which may be the same or different, are independently hydrogen atom, linear or branched C1 - C18 alkyl, carboxyl, hydroxyl, C1 - C18 alkoxy, amino or halogen atoms.

Suitable cations for use in the above-mentioned monoazo complex dyes are H⁺; cations of alkali metal, ammonium ion, cations of organic amine including aliphatic primary, secondary and tertiary amines, quaternary ammonium ion.

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Suitable amines for use in producing the above-mentioned monoazo complex dyes and common in dyestuffs include aliphatic amine, alicyclic amine, alkoxyalkyl amine, amine having alkanol, diamine, amine of guanidine derivatives, and aromatic amine.

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Examples of the monoazo complex dyes of formula [V], wherein B¹ and B² are of the formula [V-a] are below and in Table 4.

Formula [V-c]:

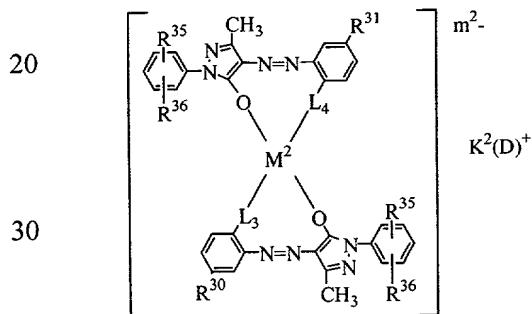


Table4

Pro. Ex. No	R ³⁰	R ³¹	R ³⁵	R ³⁶	M ²	L ₃	L ₄	m ²	K ^{2(D)} ⁺
V-1	H	H	H	H	Cr	COO	COO	1	H ⁺
V-2	Cl	Cl	SO ₂ NH ₂	H	Cr	O	O	1	H ⁺
V-3	SO ₂ NH ₂	SO ₂ NH ₂	SO ₂ NH ₂	H	Cr	O	O	1	H ⁺
V-4	Cl	Cl	SO ₂ NH ₂	H	Co	O	O	1	H ⁺
V-5	SO ₂ NH ₂	SO ₂ NH ₂	H	H	Ni	O	O	1	H ⁺
V-6	H	H	SO ₂ NH ₂	H	Cu	COO	COO	1	H ⁺
V-7	H	H	H	H	Cr	COO	COO	1	C ₄ H ₉ CH(C ₂ H ₅)OC ₃ H ₆ N ⁺ H ₃
V-8	Cl	Cl	SO ₂ NH ₂	H	Cu	O	O	1	C ₁₂ H ₂₅ N ⁺ H ₂ (CH ₂ CH ₂ O) ₂ H
V-9	Cl	Cl	SO ₂ NH ₂	H	Cr	O	O	1	Na ⁺
V-10	Cl	SO ₂ NH ₂	H	Cl	Co	O	O	1	H ⁺

Pro. Ex. No. =Product Example Number

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Examples of the monoazo complex dyes of formula [V], wherein B¹ and B² are of the formula [V-b] are below and in Table 5.

Formula [V-d]:

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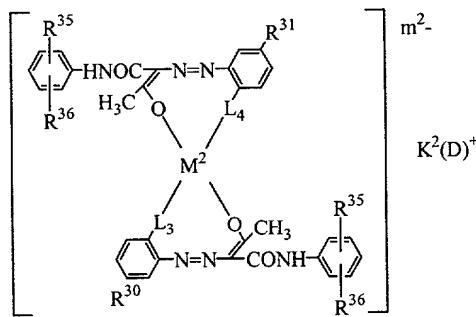


Table 5

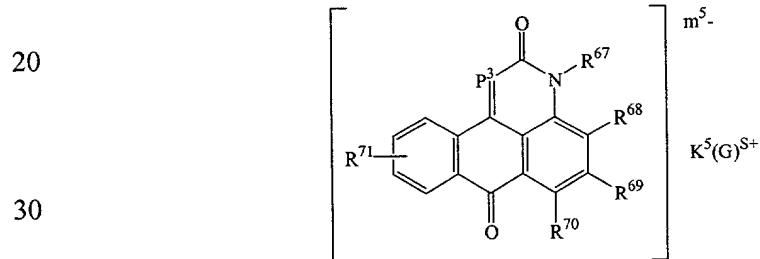
Pro. Ex. No	R ³⁰	R ³¹	R ³⁵	R ³⁶	M ²	L ₃	L ₄	m ²	K ^{2(D)} ⁺
V-11	SO ₂ NH ₂	SO ₂ NH ₂	H	H	Co	O	O	1	H ⁺
V-12	H	H	SO ₂ NH ₂	H	Cr	COO	COO	1	H ⁺
V-13	Cl	Cl	H	H	Co	O	O	1	C ₄ H ₉ CH(C ₂ H ₅)OC ₃ H ₆ N ³⁺ H
V-14	SO ₂ NH ₂	SO ₂ NH ₂	SO ₂ NH ₂	H	Cr	O	O	1	NH ₄ ⁺
V-15	Cl	Cl	SO ₂ NH ₂	H	Co	COO	COO	1	H ⁺
V-16	H	H	SO ₂ NH ₂	H	Co	COO	COO	1	H ⁺

Pro. Ex. No. =Product Example Number

5 We can obtain a black colorant having superior heat resistance by combining specific neutral anthraquinone dyes with the above mentioned monoazo complex red dyes or yellow dyes.

The above mentioned monoazo complex dyes offer superior heat resistance.

10 The anthrapyridone dyes which are mixed with the anthraquinone dyes of formula [I] or formula [II] to produce a black dye for use as colorants of the invention, can be represented by formula [VI], formula [VI]:

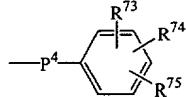


wherein R⁶⁷ to R⁷¹, which may be the same or different, are independently selected from the group consisting of H, alkyl, aryl, alkenyl, alkoxy, amino, hydroxy, halogen atom, acyl, acyloxy, acylamide, acyl-N-alkylamide, carboxyl, alkoxy carbonyl, cyclohexylamide, sulfonyl, or formula [VI-a]; and at least one of R⁶⁷ to R⁷⁴ is of sulfonyl; wherein P³ is C-R⁷² or N; R⁷² is H, alkyl, aryl, alkoxy, benzoyl, or benzyl; wherein (G)^{s+} represents ammonium ion or a cation derived from organic amine

compounds or a basic dye; wherein s is 1 or 2, m⁵ is an integer from 1 to 4 and K⁵ is the ratio of m⁵ / s;

formula [VI-a]:

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and further wherein P⁴ is O or NH, and R⁷³ to R⁷⁵, which may be the same or different, are independently selected from the group consisting of H, alkyl, aryl, alkenyl, alkoxy, 15 amino, N-alkylamide, N-arylamide, hydroxy, halogen atom, acyl, acyloxy, acylamido, acyl-N-alkylamide, carboxyl, alkoxycarbonyl, or sulfonyl.

Suitable amines for use in producing the above-mentioned anthrapyridone dyes in dyestuffs include aliphatic amine, alicyclic amine, alkoxyalkyl amine, amine having 20 alkanol, diamine, amine of guanidine derivatives, and aromatic amine.

Examples of the anthrapyridone dyes of formula [VI] are given below in Table

6.

Table 6

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Pro. Ex. No	R ⁶⁷ , R ⁶⁸ , R ⁶⁹ , R ⁷⁰ , R ⁷¹	P ³	K ⁵ (G) ^{Σ+}
VI-1	R ⁶⁸ =R ⁶⁹ =R ⁷¹ =H, R ⁶⁷ =CH ₃ , R ⁷⁰ =formula [VI-a], Formula [VI-a]:P ⁴ =NH, R ⁷³ =SO ₃ ⁻ , R ⁷⁴ =R ⁷⁵ =H	CH	H ₃ N ⁺ (CH ₂) ₆ NH ₂
VI-2	R ⁶⁸ =R ⁶⁹ =R ⁷¹ =H, R ⁶⁷ =CH ₃ , R ⁷⁰ =formula [VI-a], Formula [VI-a]:P ⁴ =NH, R ⁷³ =SO ₃ ⁻ , R ⁷⁴ =R ⁷⁵ =H	CH	(CH ₃) ₃ N ⁺ C ₁₂ H ₂₅
VI-3	R ⁶⁸ =R ⁶⁹ =R ⁷¹ =H, R ⁶⁷ =CH ₃ , R ⁷⁰ =formula [VI-a], Formula [VI-a]:P ⁴ =NH, R ⁷³ =SO ₃ ⁻ , R ⁷⁴ =R ⁷⁵ =H	CH	C ₂ H ₅ OC ₃ H ₆ N ⁺ H ₃
VI-4	R ⁶⁸ =R ⁶⁹ =R ⁷¹ =H, R ⁶⁷ =CH ₃ , R ⁷⁰ =formula [VI-a], Formula [VI-a]:P ⁴ =NH, R ⁷³ =SO ₃ ⁻ , R ⁷⁴ =CH ₃ , R ⁷⁵ =H	CH	C ₄ H ₉ N ⁺ H ₃
VI-5	R ⁶⁸ =R ⁶⁹ =R ⁷¹ =H, R ⁶⁷ =CH ₃ , R ⁷⁰ =formula [VI-a], Formula [VI-a]:P ⁴ =NH, R ⁷³ =SO ₃ ⁻ , R ⁷⁴ =CH ₃ , R ⁷⁵ =H	CH	N-trimethyl-N-benzyl Anmmonium
VI-6	R ⁶⁸ =R ⁶⁹ =R ⁷¹ =H, R ⁶⁷ =CH ₃ , R ⁷⁰ =formula [VI-a], Formula [VI-a]:P ⁴ =NH, R ⁷³ =R ⁷⁴ =SO ₃ ⁻ , R ⁷⁵ =H	CH	2(CH ₃) ₄ N ⁺
VI-7	R ⁶⁸ =R ⁶⁹ =R ⁷¹ =H, R ⁶⁷ =CH ₃ , R ⁷⁰ =formula [VI-a], Formula [VI-a]:P ⁴ =NH, R ⁷³ =SO ₃ ⁻ , R ⁷⁴ =C ₄ H ₉ , R ⁷⁵ =H	CH	C ₁₂ H ₂₅ N ⁺ H ₂ (CH ₂ CH ₂ O) ₂ H
VI-8	R ⁶⁸ =R ⁶⁹ =R ⁷¹ =H, R ⁶⁷ =CH ₃ , R ⁷⁰ =formula [VI-a], Formula [VI-a]:P ⁴ =NH, R ⁷³ =SO ₃ ⁻ , R ⁷⁴ =Cl, R ⁷⁵ =H	CH	N-trimethyl-N-benzyl Anmmonium
VI-9	R ⁶⁸ =R ⁶⁹ =R ⁷¹ =H, R ⁶⁷ =CH ₃ , R ⁷⁰ =formula [VI-a], Formula [VI-a]:P ⁴ =NH, R ⁷³ =SO ₃ ⁻ , R ⁷⁴ =CH ₃ , R ⁷⁵ =H	N	C ₂ H ₅ OC ₃ H ₆ N ⁺ H ₃

VI-10	$R^{68}=R^{69}=H, R^{67}=CH_3, R^{70}=\text{formula [VI-a]},$ Formula [VI-a]: $P^4=NH, R^{73}=SO_3^-, R^{74}=C_8H_{17}, R^{75}=H$	N	$C_{12}H_{25}N^+H_3$
VI-11	$R^{68}=R^{69}=H, R^{67}=H, R^{70}=\text{formula [VI-a]},$ Formula VI-a: $P^4=NH, R^{73}=SO_3^-, R^{74}=R^{75}=CH_3$	$C-C_6H_9$	Bis(p-methylphenyl) guanidine ammonium
VI-12	$R^{67}=R^{69}=H, R^{68}=\text{formula [VI-a]-1},$ $R^{70}=\text{formula [VI-a]-2},$ Formula [VI-a]-1: $P^4=O, R^{73}=SO_3^-, R^{74}=C_{13}H_{27}, R^{75}=H$ Formula [VI-a]-2: $P^4=NH, R^{73}=SO_3^-, R^{74}=R^{75}=CH_3$	$C-benzoyl$	$(CH_3)_3N^+C_{12}H_{25}$
VI-13	$R^{67}=R^{69}=H, R^{68}=\text{formula [VI-a]-1},$ $R^{70}=\text{formula [VI-a]-2},$ Formula [VI-a]-1: $P^4=O, R^{73}=SO_3^-, R^{74}=CH_3, R^{75}=H$ Formula [VI-a]-2: $P^4=NH, R^{73}=SO_3^-, R^{74}=R^{75}=CH_3$	$C-benzoyl$	N-trimethyl-N-benzyl ammonium
VI-14	$R^{68}=R^{69}=H, R^{67}=CH_3, R^{70}=\text{formula [VI-a]},$ Formula [VI-a]: $P^4=O, R^{73}=SO_3^-, R^{74}=R^{75}=H$	$C-benzoyl$	$(C_6H_5)_3N^+$
VI-15	$R^{68}=R^{69}=H, R^{67}=CH_3, R^{70}=\text{formula [VI-a]},$ Formula [VI-a]: $P^4=NH, R^{73}=SO_3^-, R^{74}=R^{75}=H$	CH	N-trimethyl-N-benzyl ammonium
VI-16	$R^{68}=R^{69}=H, R^{67}=CH_3, R^{70}=\text{formula [VI-a]},$ Formula [VI-a]: $P^4=NH, R^{73}=SO_3^-, R^{74}=CH_3, R^{75}=H$	CH	$H_3N^+(CH_2)_6NH_2$
VI-17	$R^{68}=R^{69}=H, R^{67}=CH_3, R^{70}=\text{formula [VI-a]},$ Formula [VI-a]: $P^4=NH, R^{73}=SO_3^-, R^{74}=C_8H_{17}, R^{75}=H$	N	Diphenylguanidine ammonium

Pro. Ex. No.=Product Example Number

The anthraquinone dyes which absorb less than 500 nm and have colors such

5 as yellow, orange and red, can be mixed with the neutral anthraquinone to produce black colors are described in the COLOR INDEX below .

Red dyes:

C.I. Solvent Red 52, 57, 111, 114, 136, 137, 138, 139, 143, 144, 145, 146, 147,
148, 149, 150, 151, 152, 155, 156, 168, 169, 170, 171, 172, 177, 181, 190, 191, 194,
10 199, 200, 201.

Orange dyes:

C.I. Solvent Orange 35, 55, 64, 65, 66, 68, 69, 71, 77, 86, 87, 163.

Yellow dyes:

C.I. Solvent Yellow 100, 109, 117, 125, 156, 158, 163 or C.I. Vat Yellow 1, 2,
15 3.

Compositions suitable to produce the black dyes are reviewed immediately below.

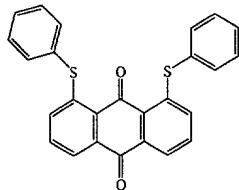
EXAMPLE 1 –black dye

The neutral anthraquinone dye of the formula [I-2]: perinone red dye of the formula [IV-3]: anthraquinone yellow dye of the following formula [a] in a weight ratio of 5: 3:

2.

5 Formula [a]:

15



EXAMPLE 2–black dye

The neutral anthraquinone dye of the formula [I-3]: perinone red dye of the formula [IV-3]: anthraquinone yellow dye of the following formula [a] in a weight ratio of 5: 4:

1.

20

EXAMPLE 3 –black dye

The neutral anthraquinone dye of the formula [II-9]: perinone red dye of the formula [IV-2]: anthraquinone yellow dye of the formula [a] in a weight ratio of 6: 3: 1.

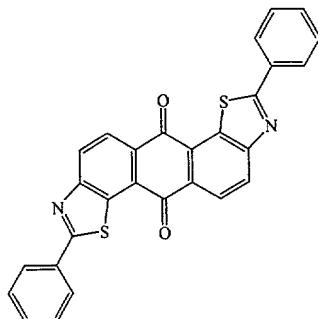
25 EXAMPLE 4 –black dye

The neutral anthraquinone dye of the formula [II-3]: perinone red dye of the formula [IV-3]: anthraquinone yellow dye of the following formula [b] in a weight ratio of 3: 2:

1.

Formula [b]:

35



EXAMPLE 5 –black dye

The neutral anthraquinone dye of the formula [I-4]: monoazo complex dye of the formula [V-2]: anthraquinone yellow dye of the formula [a] in a weight ratio of 6: 2: 1.

5 EXAMPLE 6 –black dye

The neutral anthraquinone dye of the formula [I-5]: monoazo complex dye of the formula [V-3]: anthraquinone yellow dye of the formula [b] in a weight ratio of 5: 2: 1.

EXAMPLE 7 –black dye

10 The neutral anthraquinone dye of the formula [II-4]: monoazo complex dye of the formula [V-2]: anthraquinone yellow dye of the formula [a] in a weight ratio of 5: 3: 2.

EXAMPLE 8 –black dye

15 The neutral anthraquinone dye of the formula [I-1]: anthrapyridone dye of the formula [VI-5]: anthraquinone yellow dye of the following formula [a] in a weight ratio of 5: 4: 1.

EXAMPLE 9 –black dye

20 The neutral anthraquinone dye of the formula [I-2]: anthrapyridone dye of the formula [VI-2]: monoazo complex dye of the formula [V-16]: in a weight ratio of 5: 3: 1.

EXAMPLE 10 –black dye

25 The neutral anthraquinone dye of the formula [II-4]: monoazo complex dye of the formula [V-2]: anthraquinone yellow dye of the formula [b] in a weight ratio of 6: 3: 1.

30 The resins utilized as the molded resins for laser welding may be any resin as long as they are thermoplastic resins. Polyamide resins and polyester resins are preferred from the point of view of heat-resistance and transmitting property, although other thermoplastic resins including polycarbonate resins can be used as well, alone, in combination with each other, or in combination with those preferable resins above.

Several examples of polyamide resins suitable for use in the present invention

include condensation products of dicarboxylic acids and diamines, condensation products of aminocarboxylic acids and ring-opening polymerization products of cyclic lactams. Examples of dicarboxylic acids useful in this application include adipic acid, azelaic acid, sebacic acid, dodecanedioic acid, isophthalic acid and terephthalic acid.

5 Examples of suitable diamines include tetramethylene diamine, hexamethylene diamine, octamethylene diamine, nonamethylene diamine, dodecamethylene diamine, 2-methylpentamethylene diamine, 2-methyloctamethylene diamine, trimethylhexamethylene diamine, bis(p-aminocyclohexyl)methane, m-xylene diamine and p-xylene diamine. As an example of aminocarboxylic acid, 11-aminododecanoic
10 acid can be used. Examples of useful cyclic lactams include caprolactam and laurolactam. Specific examples of condensation products and ring-opening polymerization products include aliphatic polyamides such as nylon 6, nylon 66, nylon 46, nylon 610, nylon 612, nylon 11, nylon 12, semi-aromatic polyamides such as polymetaxylene adipamide (nylon MXD-6), polyhexamethylene terephthalamide (nylon
15 6T), polyhexamethylene isophthalamide (nylon 6I) and polynonamethylene terephthalamide (nylon 9T), and copolymers and mixtures of these polymers. Examples of useful copolymers include nylon 6/66, nylon 66/6I, nylon 6I/6T and nylon 66/6T.

A wide range of common polyester molding compositions useful for blending with colorants in the practice of the present invention are known in the art. These
20 include polymers which are, in general, condensation products of dicarboxylic acids and diols. Dicarboxylic acids can be selected from the group consisting of adipic acid, azelaic acid, sebacic acid, dodecanedioic acid, terephthalic acid, isophthalic acid, naphthalenedicarboxylic acid and diphenyl dicarboxylic acid, and diols can be selected from the group consisting of ethylene glycol, propylene glycol, butanediol, hexanediol,
25 neopentyl glycol, cyclohexanediol, and bisphenol A. Preferred polyesters include polyethylene terephthalate (PET), polypropylene terephthalate (3GT), polybutylene terephthalate (PBT), polyethylene 2,6-naphthalate (PEN), polycyclohexane dimethylene terephthalate (PCT) and copolymers and mixtures thereof. As the examples of the copolymers, some of dicarboxylic acids or some of diols can be added to the
30 condensation products. Polyester polymers may be copolymerized a little amount of components like trimesic acid, trimellitic acid, pyromellitic acid, glycerol, and pentaerythritol which have more than 3 functional groups.

Additional other polymers including polycarbonate can also be presented, provided that the essential characteristics of the composition of the present invention are not substantially altered.

A black colorant useful in the composition of the invention preferably

- 5 comprises a mixture of neutral anthraquinone dye which imparts colors of blue, absorbs visible light with wavelength less than 700 nm and transmits a laser beam with wavelength at 800 nm to 1200 nm in infra-red region with at least other red dyes which transmit the laser beam with wavelength at 800 nm to 1200 nm in infra-red region, such as perinone dyes or monoazo complex dyes, at predetermined weight ratios.

10

The black colorant containing the neutral anthraquinone dye is present in amounts of from 0.01 to 1 % by weight, when the composition comprises polyamide 6 as at least the major component of the polyamide resin composition. The amount of the above-mentioned dye mixture may be determined by applications requiring different properties associated with the laser welding.

15

The composition of the present invention may contain an inorganic filler or reinforcing agent that includes, for example, fibrous reinforcement such as glass fiber and carbon fiber, glass beads, glass flakes, talc, kaolin, wollastonite, silica, calcium carbonate, potassium titanate and mica. Preferable among them is glass fiber. Glass fibers suitable for use in the present invention are those generally used as reinforcing agents for thermoplastic resins and thermosetting resins.

20

One or more optional compounds selected from a wide variety of compounds tailored for different applications of the resin compositions can be contained in the composition according to the present invention.

25

Typically, additive compounds can include flame retardants, impact modifiers, viscosity modifiers, heat resistance improvers, lubricants, antioxidants and UV-and other stabilizers. The polyamide resin composition of the present invention may have such additive compounds in such amounts that they do not harm its characteristic properties.

In the present invention, there is provided thermoplastic resin compositions suitable for laser welding, which prepare transparent articles for laser beam to achieve welding together with the opaque article for laser beam. Suitable opaque articles and its 5 compositions are described for example in DE-A-4432081.

Having reference to the drawings herein, Figure 1 is an illustration of a conventional welding arrangement. A laser beam 1 is transmitted through the first article 2 to the second article 3 containing laser beam absorbing combination, and the 10 surface 4 of the article 3 that have absorbed the laser energy is melted and pressed with the surface of the first article 2 to weld them together. As shown in Figure 2, two thermoplastic components 5 and 6 must have different transmission and absorption coefficients and it is difficult to weld at surface 8 two articles having the same color. In Fig. 2 the laser beam 1 is applied to the surface 7 of the component 5.

15 In Figures 3 and 5 herein, there is shown a lower test piece 10 used in the laser welding test of these examples. The noted dimensions creates a notch in the test piece 10. The upper test piece 9 is of the same construction and dimensions. In Figures 4 and 6, there is shown the joinder of the upper test piece 9 to lower test piece 10, and the movement of the laser 11(in the direction of the arrow) to form the weld.

20

EXAMPLES

The present invention is illustrated by the following examples and comparative examples.

25 Example A

Unreinforced nylon 6 ZYTEL® pellets (available from EI DuPont de Nemours & Co. under the name ZYTEL® 7301) was dried at 120°C for more than 8 h using a drying apparatus, and weighed according to the following formulation.

30 Nylon 6 400g
Anthraquinone blue dye of the following formula [I-2] 0.40g
Perinone red dye of the following formula [IV-3] 0.24g

Anthraquinone yellow dye of the following formula [a] 0.16g

The above formula product was agitated and mixed for 1 h in a stainless steel tumbler.

For this and all other testing involving this particular grade of nylon, A homogeneous, black experimental piece (48 x 86 x 3 (mm)) having excellent
5 appearance and surface gloss with no color unevenness was obtained after the aforementioned resulting mixture was injection molded by a usual method at 250°C cylinder temperature and 60°C molding temperature using an injection molding machine (Product of Kawaguchi Tekko Co., trade name: K50-C). The experimental piece obtained after keeping in an injection molding machine for 15 minutes was
10 fadeless.

Example B

Nylon 6 (same as Example A) 400g

15 Anthraquinone blue dye of the following formula [I-4] 0.36g

Perinone red dye of the following formula [IV-3] 0.28g

Anthraquinone yellow dye of the following formula [b] 0.16g

The above formula product was agitated and mixed for 1 h in a stainless steel tumbler.

Test pieces were prepared and tested as described for Example A, above,
20 and the results are reported in Table 7, below. The experimental piece obtained after keeping in an injection molding machine for 15 minutes was fadeless.

Comparative Example C

25 Nylon 6 (same as Example A) 400g

Anthraquinone violet dye of the following formula [c] 0.68 g

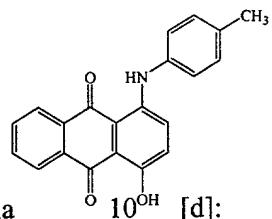
Quinophthalone yellow dye of the following formula [d] 0.12g

The above formula product was agitated and mixed for 1 h in a stainless steel tumbler.

Test pieces were prepared and tested as described for Example A,
30 above, and the results are reported in Table 7, below. The experimental piece obtained after keeping in an injection molding machine for 15 minutes was faded and uneven.

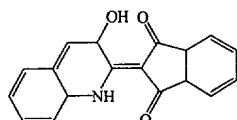
formula [c]:

5



formula 10^{OH} [d]:

15



Comparative Example D

20

Nylon 6 (same as Example A) 400g

Anthraquinone green dye of the following formula [e] 0.48 g

Anthraquinone red dye of the following formula [f] 0.32 g

The above formula product was agitated and mixed for 1 h in a stainless steel tumbler.

25

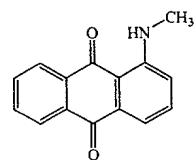
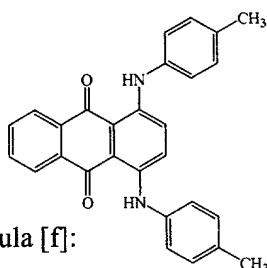
Test pieces were prepared and tested as described for Example A, above, and the results are reported in Table 7, below. The experimental piece obtained after keeping in an injection molding machine for 15 minutes was faded and uneven.

30

formula [e]:

40

formula [f]:

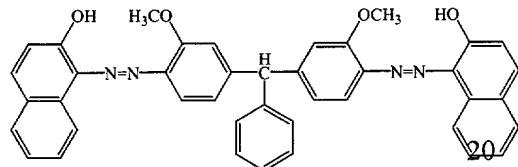


Comparative Example E

5 Nylon (same as Example A) 400g
 Anthraquinone green dye of the following formula [e] 0.48 g
 Disazo red dye of the following formula [g] 0.32 g
 The above formula product was agitated and mixed for 1 h in a stainless steel tumbler.
 Test pieces were prepared and tested as described for Example A, above,
 10 and the results are reported in Table 7, below. The experimental piece obtained after
 keeping in an injection molding machine for 15 minutes was faded and uneven.

formula [g]:

15



Comparative Example F

25 Nylon 6 (same as Example A) 400g
 Anthraquinone blue dye of the following formula [h] 0.53g
 Perinone red dye of the following formula [IV-3] 0.18g
 Anthraquinone yellow dye of the following formula [a] 0.09g
 The above formula product was agitated and mixed for 1 h in a stainless steel tumbler.
 Test pieces were prepared and tested as described for Example A,
 30 above, and the results are reported in Table 7, below. The experimental piece obtained
 after keeping in an injection molding machine for 15 minutes was faded and uneven.

formula [h]:

35

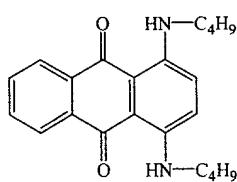


Table7

		Example A	Example B	Comparative Example C	Comparative Example D	Comparative Example E	Comparative Example F
Transmission	TA	0.96	0.97	0.90	0.95	0.95	0.95
	TB	1.00	1.02	0.85	0.86	0.94	0.97
OD		2.42	2.42	2.45	2.42	2.42	2.39
Thermal Resistance ΔE		0.46	0.38	1.73	1.55	1.62	1.86
Moisture Resistance ΔE		0.75	0.68	1.08	1.56	2.73	1.14
TG/DTA Exothermic peak(°C)/ Endothermic peak(°C)		363.3/ none	359.1/ none	320.9/ 179.5	369.7/ 154.6	367.2/ 196.2	327.4/ 102.4

5 This testing demonstrates that thermal and moisture resistance showed no deterioration in Examples A and B. Particularly, Examples A and B have no endothermic peak in TG/DAT analysis. This means that even if the composition such as Examples A and B are kept in an injection molding machine for a time(for instance, 15 minutes), the experimental piece obtained by molding has property not to fade. On the other hand,

10 Comparative Examples C, D, E and F having endothermic peak in less than Nylon 6 melting point have great possibility to fade after molding in that same way. The bigger an injection molding machine is, more important heat keeping property in it is.

15

Example G

Unreinforced polyester (prepared from terephthalic acid and ethylene glycol the intrinsic viscosity of which is 0.85 when measured at 25 °C as a 1% solution in a mixed solution of phenol and dichlorobenzene with the weight ratio of 1/1) was dried at 20 120°C for more than 8 h using a vacuum drying apparatus, and weighed according to the following formulation.

Polyester	.... 400g
Anthraquinone blue dye of the following formula [II-9]	.... 0.40g
Perinone red dye of the following formula [IV-3]	.... 0.24g
Anthraquinone yellow dye of the following formula [a]	.... 0.16g

The above formula product was agitated and mixed for 1 h in a stainless steel tumbler.

For this and all other testing involving this particular grade of polyester, A homogeneous, black experimental piece (48 x 86 x 3 (mm)) having excellent appearance and surface gloss with no color unevenness was obtained after the 5 aforementioned resulting mixture was injection molded by a usual method at 290°C cylinder temperature and 60°C molding temperature using an injection molding machine (Product of Kawaguchi Tekko Co., trade name: K50-C). The experimental piece obtained after keeping in an injection molding machine for 15 minutes was fadeless.

10

Example H

Polyester (same as Example G)	.... 400g
15 Anthraquinone blue dye of the following formula [I-2]	.... 0.40g
Perinone red dye of the following formula [IV-3]	.... 0.24g
Anthraquinone yellow dye of the following formula [a]	.... 0.16g

The above formula product was agitated and mixed for 1 h in a stainless steel tumbler.

Test pieces were prepared and tested as described for Example G, above, 20 and the results are reported in Table 8, below. The experimental piece obtained after keeping in an injection molding machine for 15 minutes was fadeless.

Example I

Polyester(same as Example G)	.... 400g
Anthraquinone blue dye of the following formula [I-4]	.... 0.36g
25 Perinone red dye of the following formula [IV-3]	.... 0.28g
Anthraquinone yellow dye of the following formula [b]	.... 0.16g

The above formula product was agitated and mixed for 1 h in a stainless steel tumbler.
Test pieces were prepared and tested as described for Example G, above, 30 and the results are reported in Table 8, below. The experimental piece obtained after keeping in an injection molding machine for 15 minutes was fadeless.

Comparative Example J

Polyester (same as Example G)	.... 400g
Anthraquinone violet dye of the following formula [c]	.... 0.68 g
5 Quinophthalone yellow dye of the following formula [d]	.... 0.12g

The above formula product was agitated and mixed for 1 h in a stainless steel tumbler.

Test pieces were prepared and tested as described for Example G, above, and the results are reported in Table 8, below. The experimental piece obtained after keeping in an injection molding machine for 15 minutes was faded and uneven.

10

Comparative Example K

Polyester (same as Example G)	.... 400g
15 Anthraquinone green dye of the following formula [e]	.... 0.48 g
Anthraquinone red dye of the following formula [f]	.... 0.32 g

The above formula product was agitated and mixed for 1 h in a stainless steel tumbler.

Test pieces were prepared and tested as described for Example G, above, and the results are reported in Table 8 , below. The experimental piece obtained after
20 keeping in an injection molding machine for 15 minutes was faded and uneven.

Comparative Example L

Polyester (same as Example G)	.... 400g
25 Anthraquinone green dye of the following formula [e]	.... 0.48 g
Disazo red dye of the following formula [g]	.... 0.32 g

The above formula product was agitated and mixed for 1 h in a stainless steel tumbler.

Test pieces were prepared and tested as described for Example G, above, and the results are reported in Table 8, below. The experimental piece obtained after
30 keeping in an injection molding machine for 15 minutes was faded and uneven.

Comparative Example M

Polyester(same as Example G) 400g
 Anthraquinone blue dye of the following formula [h] 0.53g
 5 Perinone red dye of the following formula [IV-3] 0.18g
 Anthraquinone yellow dye of the following formula [a] 0.09g

The above formula product was agitated and mixed for 1 h in a stainless steel tumbler.

Test pieces were prepared and tested as described for Example G, above, and the results are reported in Table 8, below. The experimental piece obtained after keeping 10 in an injection molding machine for 15 minutes was faded and uneven.

Table8

		Example G	Example H	Example I	Comparative Example J	Comparative Example K	Comparative Example L	Comparative Example M
Transmission	TA	0.88	0.93	0.93	0.92	0.93	0.92	0.93
	TB	0.85	0.93	0.93	0.89	0.93	0.89	0.96
OD		1.78	1.81	1.80	1.86	1.78	1.85	1.78
Moisture Resistance ΔE		3.15	3.56	3.30	5.02	4.64	4.48	4.55
Sublimation Test ΔE		5.32	9.72	7.07	19.33	12.36	11.97	17.42
TG/DTA Exothermic peak($^{\circ}$ C)/Endothermic peak($^{\circ}$ C)		532.8/none	363.3/none	359.1/none	320.9/179.5	369.7/154.6	367.2/196.2	327.4/102.4

15 This testing demonstrates that moisture resistance showed no deterioration in Examples G, H and I. Particularly, Examples G, H and I showed low sublimation, compared with Comparative J, K, L and M. Therefore, even if thermoplastic resin composition colored by Examples G, H or I is put on higher temperature space as like 20 automobile or electric industry, its colorant have property not to migrate other parts. And in heat keeping property in an injection molding machine, the result same as Nylon 6 can be occurred.

Test Procedures

(1) Transmission Properties

Transmittance (T) in the range of 400 nm to 1200 nm of the test plates with laser beams having respective wavelengths of 940 nm(Semiconductor laser) and 1064 nm (YAG laser) was measured using a U-3410 spectrometer produced by Hitachi with 60 ϕ sphere photometer for wavelength from ultraviolet to near-infrared. The ratio (TA) of transmission with 940 nm: transmission with 1064 nm and the ratio (TB) of transmission with 940 nm: transmission of natural resin are determined and compared between the examples.

10

(2) Appearance and surface gloss

Appearance of the test plates were evaluated by measuring Reflection Density (OD) of the test plates by Reflection Density meter TR-927 produced by Macbeth. Test plates having higher OD values are judged to have better surface smoothness and rich in gloss.

15
(3) Thermal Resistance

The amount of color fading and discoloration ΔE between "before" and "after" each test plate being placed and kept in an oven at 160°C for 15 days was determined and measured using a colorimeter (produced by Juki, trade name: JP 7000).

20
(4) Moisture Resistance

The amount of color fading and discoloration ΔE between "before" and "after" each test plate being placed and kept in a thermoregulator at 80°C(a humidity was 95%) for one week was determined and measured using a colorimeter (produced by Juki, trade name: JP 7000).

25
(5) TG(Thermogravimetric analyzers) / DTA (Differential thermal analyzers)

TG and DTA of each test colorant powder were measured using TG / DTA analyzers (produced by Seiko Instrument, trade name:SII EXSTAR 6000) in a heating furnace that air is introduced into at 200 ml / min, of which temperature is raised from

30 to 55° C at 10 °C/min then when reached to at 550 °C for 28 minutes.

(6) Sublimation Test

The amount of dye sublimation was determined by E between before and
5 after white tape attached on each test plate being placed and kept in an oven at 140°C
for 3 hours and was measured using a colorimeter (produced by Juki, trade name: JP
7000).

The white tape attached on the test plate having greater E are judged to have
greater sublimation.

10

Example N and comparative Example O and P

Fiberglass reinforced nylon 6 (Zytel®73G30L, available from E. I. DuPont de Nemours
and Co.) and dyes were dry-blended with the amount described in Table 9. The blended
material was molded into two types of test pieces: one for mechanical properties, and
15 the other for laser welding. Test pieces for mechanical properties were molded
according to the ISO3167 on the Toshiba IS 170FIII injection molding machine, with
cylinder temperature set at 260°C and mold temperature at 80°C. Test pieces for laser
welding, with dimensions illustrated as Figure 3, were molded on the Sumitomo Juki
75T injection molding machine, with cylinder temperature set at 250°C and mold
20 temperature set at 80°C.

Tensile strength and elongation were measured according to ISO527 and notched
Charpy impact strength was measured according to ISO179.

Laser welding was conducted using two of the test pieces described above, combined as
illustrated in Figure 4. The Example N and the Comparative Example O were used as
25 Upper test piece and the Comparative Example P was used as Lower test piece. A diode
laser (wavelength 940nm, manufactured by Rofin-Sinar Laser GmbH) was irradiated
with laser power at 50W and various speeds, with 3mm diameter. Tensile strength of
the welded test pieces were measured on the Autograph (manufactured by Shimazu
Seisakusho) by pulling apart at 5mm/minute and its maximum load was recorded.

Table 9

		Example N	Comp. Ex O	Comp. Ex. P
73G30L	kg	4.9925	4.9925	4.99
Blue dye formula [I-2]		3.75g		
Red dye formula [IV-3]		2.25g		
Yellow dye formula [a]		1.50g		
Green dye formula [e]			4.50g	
Red dye formula [g]			3.00g	
Carbon black				10g
Tensile strength	MPa	174	181	185
Elongation	%	3.9	4.2	3.4
Notched Charpy	KJ/m ²	12.8	13.3	12.2
Laser Welding at 50W				
2.5m/min	Kgf	195	189	-
5m/min	Kgf	196	177	-
10m/min	Kgf	115	110	-

Example Q and Comparative Example R and S

Fiberglass reinforced nylon 66 (Zytel®70G33HS1L, available from E. I. DuPont de

5 Nemours and Co.) and dyes were dry-blended with the amount described in the Table
 10. The blended material was molded into two types of test pieces: one for mechanical
 properties, and another for laser welding. Test pieces for mechanical properties were
 molded according to the ISO3167 on the Toshiba IS 170FIII injection molding machine,
 with cylinder temperature set at 280°C and mold temperature at 80°C. Test pieces for
 10 laser welding, with dimensions illustrated in Figure 3, were molded on the Sumitomo
 Juki 75T injection molding machine, with cylinder temperature set at 270°C and mold
 temperature set at 80°C.

Tensile strength and elongation were measured according to ISO527 and notched
 Charpy impact strength was measured according to ISO179.

15 Laser welding was conducted using two pieces of the test pieces described above,
 combined as illustrated in Figure 4. The Example Q and the Comparative Example R
 were used as Upper test piece and the Comparative Example S was used as Lower test
 piece. Diode laser (wavelength 940nm, manufactured by Rofin-Sinar Laser GmbH) was
 irradiated with the power at 80W and at various speeds with 3mm diameter. Tensile
 20 strength of the welded test pieces was measured on Autograph (manufactured by

Shimazu Seisakusho) by pulling apart at 5mm/minute and its maximum load was recorded.

Table 10

		Example Q	Comp. Ex. R	Comp. Ex. S
70G33HS1L	kg	4.9925	4.9925	4.99
Blue dye formula [I-4]		3.75g		
Red dye formula [IV-3]		2.25g		
Yellow dye formula [a]		1.50g		
Green dye formula [e]			4.50g	
Red dye formula [g]			3.00g	
Carbon black				10g
Tensile strength	MPa	199	207	207
Elongation	%	3.4	3.8	3.2
Notched Charpy	kJ/m ²	12.3	13.5	11.9
Laser Welding at 80W				
2.5m/min	kgf	97	75	-
5m/min	kgf	195	185	-
10m/min	kgf	194	187	-

5

Example T - Example V, Comparative Example W - AA

Pellets of unreinforced nylon 6 (Zytel→7301, available from E. I. DuPont de Nemours and Co.) and dyes were dry-blended with the amount described on the table 11. The
10 blended material was molded into test pieces for laser welding, with dimension illustrated as Figure 5, on the K50-C injection molding machine (manufactured by Kawaguchi Steel K.K.) with cylinder temperature set at 250°C and mold temperature set at 60°C.

Laser welding was conducted using two pieces of the test pieces described above,
15 combined as illustrated in Figure 6. Each Example from T to V and Comparative Example from W to Z was used as Upper test piece and Comparative Example AA was used as Lower test piece. Diode laser (wavelength 940nm, manufactured by Rofin-Sinar Laser GmbH) was irradiated at 50W power and with speed at 1m/minute, with 3mm diameter. Strength of the welded test pieces was measured on Autograph (manufactured
20 by Shimazu Seisakusho) by pulling apart at 50mm/minute and its maximum load was recorded.

Table 11

	Example T	Example U	Example V	Comp. Ex. W	Comp. Ex. X	Comp. Ex. Y	Comp. Ex. Z	Comp. Ex. AA
Nylon 6	400g	400g	400g	400g	400g	400g	400g	400g
Blue dye formula [I-4]	0.40g							
Red dye formula [IV-3]	0.24g	0.24g	0.24g				0.18g	
Yellow dye formula [a]	0.16g	0.16g	0.16g				0.09g	
Blue dye formula [II-9]			0.40g					
Blue dye formula [I-2]				0.40g				
Violet dye formula [c]					0.68g			
Yellow dye formula [d]					0.12g			
Green dye formula [e]						0.48g		
Red dye formula [f]						0.32g		
Red dye formula [g]						0.32g		
Blue dye formula [h]							0.53g	
NUBIAN COMPLEX BLACK G04								0.80g
Transmittance at 940nm (2mm thick)								
Laser Weld Strength (kgf)	170	151	292	194	195	171	188	-

NUBIAN COMPLEX BLACK G04 (Product name: product of Orient Chemical Industries Ltd): a mixture of carbon and nigrosine.

5

Example AB and comparative Example AC-AE

Fiberglass reinforced polyester (prepared from terephthalic acid and ethylene glycol the intrinsic viscosity of which is 0.85 when measured at 25 °C as a 1% solution in a mixed solution of phenol and dichlorobenzene with the weight ratio of 1/1 and containing 10 30wt% chopped strand glass fibers 187H produced by Nippon Electric Glass Co., Ltd. based on a total weight of the polyester resin composition, and dried as described for example G) and dyes were dry-blended with the amount described in Table 13. The blended material was molded into two types of test pieces: one for mechanical properties, and the other for laser welding. Test pieces for mechanical properties were 15 molded according to the ISO3167 on the Toshiba IS 170FIII injection molding machine, with cylinder temperature set at 290°C and mold temperature at 60°C. Test pieces for laser welding, with dimension illustrated as Figure 3, were molded on the Sumitomo

Juki 75T injection molding machine, with cylinder temperature set at 280°C and mold temperature set at 60°C.

Tensile strength and elongation were measured according to ISO527 and notched Charpy impact strength was measured according to ISO179.

- 5 Laser welding was conducted using two pieces of the test pieces described above, combined as illustrated in Figure 4. The Example AB and the Comparative Example AC-AD were used as Upper test piece and the Comparative Example AE was used as Lower test piece. Diode laser (wavelength 940nm, manufactured by Rofin-Sinar Laser GmbH) was irradiated with laser power at 50W and regular speed, with 3mm diameter.
- 10 Tensile strength of the welded test pieces were measured on Autograph (manufactured by Shimazu Seisakusho) by pulling apart at 5mm/minute and its maximum load was recorded.

Table 12

		Example AB	Comp. Ex. AC	Comp. Ex AD	Comp. Ex. AE
73G30L	kg	4.9925		4.9925	4.99
Blue dye formula [I-2]		3.75g			
Red dye formula [IV-3]		2.25g			
Yellow dye formula [a]		1.50g			
Violet dye formula [c]			6.375g		
Yellow dye formula [d]			1.125g		
Green dye formula [e]				4.50g	
Red dye formula [g]				3.00g	
Carbon black					10g
Tensile strength	MPa	135	133	135	150
Elongation	%	4.3	4.3	4.0	2.7
Notched Charpy	KJ/m ²	13.0	14.0	13.0	10.5
Laser Welding at 50W 5m/min	Kgf	150	144	145	-